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# A DROP-IN CFC-12 REPLACEMENT FOR AUTOMOTIVE AIRCONDITIONING

by

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## ABSTRACT

There currently exists a large number (millions) of automobiles with air conditioning systems designed to use CFC-12 as the refrigerant along with plans to produce such systems into the 1992-1995 time frame. During the 1992-1995 period, new production will transition to HFC-134a refrigerant based systems or other technologies which offer zero or little ozone depletion. CFC-12 based systems will finally cease production around 1995, but they will have a lifetime of about 10 years, extending the need for CFC-12, or a substitute until the year 2005 or so. This paper will present a ternary blend of refrigerants which may be able to be used as a transition refrigerant in CFC-12 designed automotive air conditioners until HFC-134a and other technologies are able to take over. Performance, oil miscibility, flammability, toxicity, and testing with a commercial dehydrant/leak sealant will be discussed.

## INTRODUCTION

A ternary blend of HCFC-22, HCFC-142b (chlorodifluoroethane), and small amount of R-600a (isobutane) has been found to provide acceptable operation on several automobile airconditioning systems designed for use with CFC-12. Some capacity increase has been noted in most systems, probably from the blend being non-azeotropic, leading to better utilization of the condenser and evaporator [1]. This blend features 95% less ozone depletion potential (ODP) than does CFC-12 (ODP of 0.05 vs CFC-12 with ODP 1.0). This blend is 55% HCFC-22, 37% HCFC-142b, and 8% isobutane by weight and is compatible with mineral oils currently used in CFC-12 systems.

Testing began in August 1990 in two vehicles, a 1990 Pontiac Transsport, and a 1978 Datsun 810. A 1979 Grand Prix was added in October 1990. By March 1992, some 150 vehicles were running this blend. Only one failure has occurred. A 1984 Buick Century had a DA-6 compressor fail. The tear down of the compressor revealed the thin Teflon piston rings had broken, and fragments had lodged in the valves, holding them open. Local mechanics state this is an extremely common failure mode for this compressor (with R-12), and one mechanic reported he changed 38 DA-6 compressors in a two month period during the summer of 1991 which had failed for the same reasons. The remaining intact Teflon piston rings, did not appear to be swollen or affected by this blend. Currently, there is no reason to suspect this blend as being the cause of this failure.

The first two vehicles were instrumented with gauge manifolds (all copper lines) in the passenger compartment along with thermocouple probes, so temperatures and pressures could be monitored in real life driving situations. The 1990 Transsport, ran the standard CFC-12 charge for the first year of its life, it then was charged with the ternary blend. After 8 months no loss of charge was noted from performance and pressures. Refrigerant has remained clear and dry as observed in an installed liquid line sight glass.

## PERFORMANCE

Testing of this blend has shown significant (around 2-7°C) decrease in discharge air temperatures at ambient temperatures over 27°C over that of what CFC-12 did. Condensation and evaporation of the refrigerant appear to occur over a larger band or "glide", thus achieving better utilization of the evaporator and condenser. At lower ambients, the capacity (cooling) of this blend drops off to approximately that of CFC-12, mostly from the reduction in head pressure. Different systems perform differently. CCOT (orifice) systems generally show more increase in capacity than do expansion valve systems. Compressor discharge temperatures did run slightly higher than with R-12. Hot ambient (32-38 ° C) days produced discharge temperatures in the 80°C range. The same systems had R-12 discharge temperatures in the 70°C range (average city driving). Even though slightly higher, the compressor discharge line temperatures are still low enough to prevent refrigerant/oil breakdown.

## OIL MISCIBILITY

In addition to refrigeration effect, the isobutane makes this blend miscible in standard mineral oils used in CFC-12 systems. Neither HCFC-22 nor HCFC-142b by itself are very miscible with mineral oils used in CFC-12 systems at evaporator temperatures (0°C). The "Upflow" evaporators and large diameter suction lines commonly found in R-12 systems may cause problems with oil return to the compressor, resulting in compressor failure, when the refrigerant is not miscible in the oil being used [2].

This blend stayed dissolved in oil (20% oil) by volume, at 0°C (approximate evaporation temperature in auto A/C systems) with Suniso 5GS (525 SUS viscosity) mineral oil of the type used in auto A/C systems. Suniso 3GS (150 SUS viscosity) mineral oil (naphthanic) and Virginia KMP 150 viscosity mineral oil (paraffinic) also stayed dissolved in refrigerant at 0°C. Both 150 viscosity oils were completely dissolved at -18°C. Around 10% (by volume) of Suniso 525 SUS viscosity oil dissolved in the refrigerant at -18°C. This 525 viscosity oil is normally used in auto A/C systems which only operate at 0°C or higher. Typically, around 10% by volume, oil is circulated with the refrigerant in auto A/C systems.

## FLAMMABILITY

The current blend could not be ignited, even after a 4 month leak down test (over 1/2 the charge had been lost). It should be noted that even CFC-12 can be "flammable", when it contains dissolved oil, and a rapid release occurs. The oil atomizes into a fine mist and can be ignited. It has been reported that HCFC-22/HCFC-142b mixtures are nonflammable up to concentrations of 68% weight of HCFC-142b [3].

Many "nonflammable" refrigerants, which contain hydrogen atoms, can become flammable if mixed with large amounts of air under pressure. Such examples include HCFC-22 and HFC-134a. For this reason, this blend and other refrigerants and blends containing hydrogen atoms should not be diluted with air, and pressurized (such as for leak testing). Diluting the refrigerant with dry nitrogen is ok.

Being a non-azeotrope, this blend will change composition during the leaking process. Recharging (topping off), systems with partial charges is prohibited. The entire charge must first be removed, and a recharge done with new (non recycled) material. Repeated topping off of leaking systems could lead to this blend becoming flammable, thus the requirement of always doing a full recharge with new material. This requirement should not impact automotive air conditioning severely. This difficulty rapidly becomes prohibitive in large commercial systems, where topping off leaking systems is the normal mode of operation. Non-azeotropic blends will be cumbersome in anything except automotive and small systems due to the requirement that the whole charge be removed. Reconstitution of leaking non-azeotropic blends to known composition is beyond the scope of almost all service technicians.

## TOXICITY

Unlike the new generation of "hyperfluorinated" refrigerants, all of the ingredients of this blend have existed for decades and their properties are well known. HCFC-142b is commercially available in large quantities.

## LEAKING AND LEAK SEALING IN CARS

It has been observed, that a large percentage of older (4 years or older) cars, seem to have continual slow refrigerant leaking problems. Even when the leaks are identified and repaired, many are low on charge by the following summer. New leaks form, and/or hose diffusion may be occurring and may be undetectable due to the large surface areas or difficult to access areas. Airconditioning service shops, often can only repair "obvious" leaks or change "bad" components. Some leaks have been observed to be temperature sensitive (e.g. only leaks in the winter when parts contract) Many cars are continually recharged at 2 month to 1 year intervals, since the leaks are impossible to find/repair. Many owners of older cars are not willing to pay the cost of an entire new system being installed (often over $1000), just because the leaks cannot be found and repaired. State laws are being enacted (such as Florida, 7/1/91), which prohibit automobiles from leaving a service shop unless the leak is repaired. If the leak is not repaired, then the CFC-12 must be removed from the system before releasing the car to the owner. Mechanics have reported to the author that they have encountered certain brands of connectors which always leak small amounts of charge, even if they are new and this has led to much frustration as they cannot be properly "fixed".

A commercial silane based dehydrant and sealant, has been tested with this blend. System drying and sealing of leaks has been observed to be satisfactory for the two week to 1 year "leak rates". This also stopped diffusion through hoses and helped prevent composition changes in the blend due to leaking. Elimination of constant recharging reduces the "effective" (per car) ODP further. If a car "saves" five additional recharges in its lifetime, then the effective ODP becomes 0.01 for a 99% reduction in ozone depletion from R-12. Shaft seal leaks were not repaired, but they were reduced. Use of this sealant requires the system be "dry", with no significant moisture trapped in the drier. The sealant manufacturer requires that the drier be changed prior to use. Experience has found this to be true. Using this blend [with sealant] on "wet" systems (without changing the drier), resulted in the sealant being neutralized and no sealing action. No harm was caused be this action other than sealant being wasted. The systems continued to perform (and leak) normally. Changing the drier and orifice are always good refrigeration practices. Old driers can have their desiccant bags break, and clog the system with clay from the desiccant binder.

## PROCEDURES

Being a non-azeotropic blend, certain procedures must be followed to prevent composition changes. The most obvious is that the system must be "liquid charged", carefully to avoid slugging the compressor. Systems with partially leaked charges, should be discharged before recharging, to achieve a known composition. This problem is greatly reduced by the addition of the above sealant. Under the "1990 Clean Air Act", this blend cannot be vented to the environment after certain dates (mostly in 1992), depending on the type of service (mobile airconditioning, fixed, size of service shop, etc). It can be "recovered" (pumped into a tank) with CFC-12 recovery equipment and returned to the manufacturer to be reclaimed to new standards or be destroyed, it cannot be reused on site.

## CONCLUSIONS

The author believes this blend can be used to keep existing and future CFC-12 automotive airconditioning systems running until they reach their normal end of life. This blend may take some pressure off the race to get HFC-134a, its complex lubricants and field procedures operational, for retrofitting existing CFC-12 systems which fail in the field. Being a blend, "custom" refrigerants can be made for extra performance in hot humid climates with minor system modifications (a high pressure cutout switch). Testing is currently ongoing in this area. It is possible to deliver subfreezing air continuously at ambients of 38°C (highway driving).

US and foreign patents pending.

## REFERENCES

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